

Center for Southeastern Tropical Advanced Remote Sensing (CSTARS)

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LONG-TERM GOAL

We wish to establish a high capability satellite data reception and analysis facility for environmental monitoring in the southeastern US, Gulf of Mexico, Caribbean Basin and Equatorial Atlantic. CSTARS will provide a variety of satellite data and support for scientific research in land, atmosphere, ice and ocean sciences, as well as applied applications in the fields of environmental monitoring, natural hazard assessment, civil defense and defense tactical applications.

SCIENTIFIC OBJECTIVES

To achieve these goals we are developing a high capability receiving and analysis facility for X-band satellite data with a subsequent enhanced capability that would include lower frequency L- and S-band reception. Key priorities in the system design will be high reliability data reception to low elevation angles and rapid data access for all scientific, civilian and defense tactical users.

The specific scientific objectives of this proposed project are, but not limited to air-sea interaction and ocean dynamics:

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- 1) To explore the further use of SAR imagery for retrieval of high-resolution synoptic wind fields with special emphasis on tropical storms.
- 2) To examine the surface roughness, wave breaking and directional distribution of the wave field in tropical and extra-tropical storm systems.
- 3) To explore and quantify mesoscale flow patterns in synoptic and tropical lows.
- 4) To study in more detail the morphology of hurricanes especially when coupled with information about cloud patterns and precipitation from other sensors.
- 5) To develop algorithms for improved detection of ships and their location, size and type as well as speed and direction characteristics.
- 6) To examine ocean features such as fronts, currents and eddies and combine with measurements of long-range shore-based high-frequency Doppler radars.

APPROACH

The CSTARS is the only satellite data reception and analysis facility in the world that will shortly track and receive image data from 14 electro-optical and microwave satellites. CSTARS currently operates with dual antennas at X-band (~8 GHz frequency), and is receiving data world-wide from a wide variety of low-Earth orbiting satellite (LEOS) systems. Current operational capability includes RADARSAT-1, SPOT 4 & 5, ERS-2, ENVISAT ASAR and MERIS, ALOS/PALSAR, as well as MODIS instruments on TERRA and AQUA. We also have a virtual capability for FormoSat-2 imagery. Currently CSTARS is expanding its reception and processing capability under a DoD project to add three new high-resolution synthetic aperture radars (SARs). Just recently the Italian Space Agency's four satellite system Cosmo-SkyMed was implemented and can provide global collections to DoD. By 2010 we will also have access to RadarSat-2, and TerraSAR-X and Tandem-X to support a variety of scientific missions.

CSTARS applications will remain diverse and with the higher resolution radar satellites at different imaging frequencies as well as polarizations new insights can be gained in scientific applications of land, atmosphere, ice and ocean sciences which includes environmental monitoring, natural hazard assessment, civil defense and defense tactical applications. High reliability data reception to low elevation angles (~3 degrees above the local horizon) and rapid data access for all scientific and other civilian users will be key priorities in the system operations.

WORK COMPLETED

1. Final infrastructure upgrades and modifications were completed at the CSTARS facility.
2. Through SpaceTec's XTPS processor for ENVISAT ASAR and MERIS data we can now downlink both sensors at full resolution.
3. With the support of the Alaska SAR Facility, Fairbanks, Alaska we are now a subnode to ALOS/PALSAR and can program and downlink L-Band SAR data.
4. As a partner with the Defense Intelligence Agency (DIA) we have implemented the Cosmo-SkyMed ground station capability through a Foreign Comparative Test (FCT) program.

5. Together with the National Geospatial-Intelligence Agency (NGA) we completing a SAR Pilot Project which includes RadarSat-2 and TerraSAR-X/Tandem-X to perform an operational assessment of these sensors.

RESULTS

CSTARS has leveraged its capabilities in many research projects and also supported US SouthCom in humanitarian assistance during the 2008 hurricane season that ravaged Haiti. Some examples are given below.

Tropical Cyclone and Oceanic Winds from SAR Imagery

CSTARS continues to jointly operate with the Canadian Space Agency and the European Space Agency a HurricaneWatch program to acquire in near real time SAR imagery of tropical cyclones in the Atlantic and Caribbean Basins as well as the Gulf of Mexico. This project is now in its 5th year. Because of its successful implementation we are also exploring to implement a similar program in the western Pacific for typhoons to support several ONR-funded projects. Currently there are three wind algorithms based on the CMOD-5 scatterometer GMF which are applied to C-Band SAR images of hurricanes and typhoons. A working group is examining the strengths and weaknesses of each algorithm and is working on a combined typhoon wind model that would derive vector winds directly from the radar backscatter and wind streaks of SAR imagery. Figure 1 shows the ENISAT ASAR image of Hurricane Ike as the eye just makes landfall at Galveston, TX on 13 September 2008 at 04:22 UTC and the corresponding wind field derived from the JHU/APL ANSWR system.

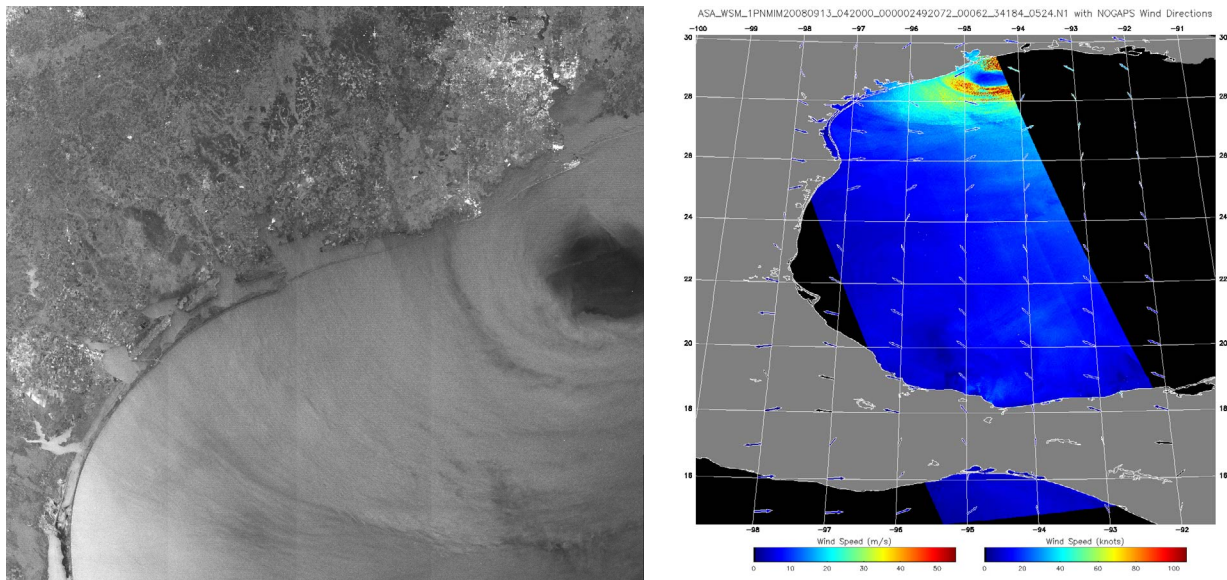


Figure 1: ENISAT ASAR image zoomed in on Hurricane Ike's eye on 13 September 2008 at 04:22 UTC (left). High resolution wind vector field of Hurricane Ike through the Gulf of Mexico (right).

Gap Winds

CSTARS also provides global collections for numerous experiments around the world. Figure 2 shows an ENISAT wide-scan ASAR image on 22 February 2008 at 01:53 UTC of strong jets emanating

from the mountain valleys of the Philippine archipelago. In the lee of the Philippine Islands, wind jets are common during the winter monsoon season as a result of steady northeasterly winds that interact with volcanic topography. Multiple SAR images from the winter monsoon in support of the ONR PhilEx program were obtained to support ship-based oceanography. We plan to use these images to study the effect of the Philippine gap winds upon the upper ocean by assessing satellite-derived sea surface temperature, chlorophyll-a, and upwelling.

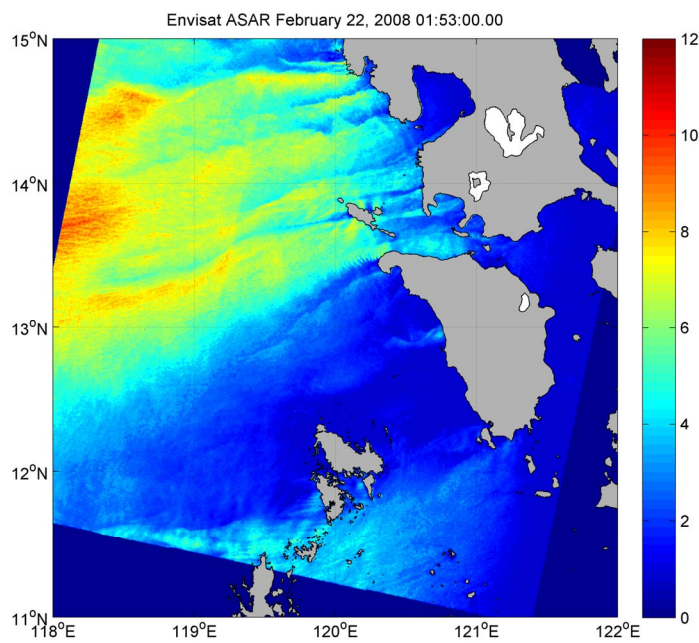


Figure 2: *ENVISAT ASAR image of gap winds over the Philippine Islands on 22 February 2008 at 01:53 UTC). The gap winds and the extent of the wind shadows as well as jets of strong winds extending seaward are readily visible in this image. Note the vortices coming off the northern tip of Mindoro Island.*

Disaster Response

In 2008 Haiti was ravaged by four major storms (three were hurricanes) that either directly passed over the island or in very close proximity. In a four week period from mid-August to mid-September extensive rainfall from these tropical system generated flooding and caused significant damage to roads, bridges and infrastructure. Figure 3 shows a TerraSAR-X image on 06 September 2008 at 22:54 UTC of the Gonaives region. The image shows that the major road leading to Gonaives was flooded and the bridge was either submerged or destroyed.

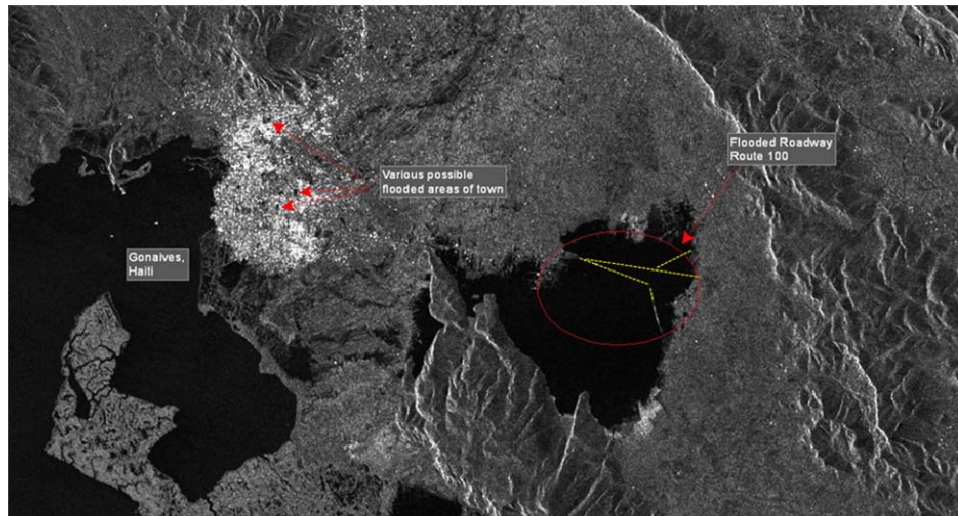


Figure 3: TerraSAR-X image on 06 September 2008 at 22:54 UTC of the mostly flooded Gonaïves region.

CSTARS provided satellite imagery to the US Southern Command for rapid assessment of humanitarian assistance and determination of the extent of damage and the state of infrastructure. These annotated products were highlighting storm damage to roads, bridges, towns, and the extent of flooding so more effective humanitarian support could be provided.

IMPACT/APPLICATION

The CSTARS facility readily exploits the frequent SAR and EO passes inside its extensive coverage from Hudson Bay in the north to the equator in the south. In particular, CSTARS continues to support state and local response in hurricane and flood emergencies, especially the US Southern Command in the Haiti 2008 relief effort. CSTARS supports a variety of ONR research projects on a global scale. CSTARS also works with other DoD agencies on time sensitive applications.

TRANSITIONS

A variety of operational products are provided to the Defense Intelligence Agency (DIA) and National Geospatial-Intelligence Agency (NGA) for evaluation. Also close collaborations exist between CSTARS and the USAF EagleVision program.

RELATED PROJECTS

Numerous projects have been spawned from the existence of CSTARS and the availability of electro-optical and microwave satellite data. These projects include:

- HurricaneWatch program over the Atlantic and Caribbean Basins and the Gulf of Mexico with the Canadian Space Agency and the European Space Agency.
- DHS project on port and maritime security.

- Tidal flat dynamics in the northwestern U.S.
- Support studies for Office of Naval Research.
- Disaster response projects for USSOUTHCOM in the Caribbean Basin.

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